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BIOLOGICAL AND NONBIOLOGICAL TRANSFORMATIONS OF MERCURY IN AQUATIC SYSTEMS

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BIOLOGICAL AND NONBIOLOGICAL TRANSFORMATIONS OF MERCURY IN AQUATIC SYSTEMS

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Biological and nonbiological transformations of heavy metals, with present emphasis on mercury, have been and are under investigation in collaboration with Dr. Rita Colwell's group at the University of Maryland.

In our studies of biological transformations, a number of mercury-tolerant bacterial isolates from Chesapeake Bay waters and sediments have been examined for their ability to volatilize mercury from trace concentrations of inorganic or organomercury compounds (e.g. $HgCl_2$ or phenylmercuric acetate). A survey for such aerobic microorganisms has been conducted;[1] these include Pseudomonas spp. which constitute about 90% of the phenylmercuric acetate-tolerant bacterial cultures obtained.

Inoculated agar plates containing phenylmercuric acetate (0.3 ppm) were placed in a bioreactor and the atmosphere surrounding the plates analyzed for total and metallic mercury using an atomic absorption (AA) spectrophotometer on-line with a bioreactor[1] (Fig. 1). The results indicated that all of the nine isolates so examined primarily produce metallic mercury. The typical production of Hg^0 from one isolate (No. 72) is shown in Fig. 2.

Currently we are in the process of examining a number of $HgCl_2$-tolerant anaerobic and facultative bacteria for their ability to produce metallic mercury and other volatile mercury compounds from $HgCl_2$ using a flameless AA spectrophotometer coupled with a vapor phase chromatograph. This approach has been previously described in another connection,[2] but our special application affords a very significant advance in direct separation and characterization of mercury-containing bacterial metabolites at environmental concentrations under con-

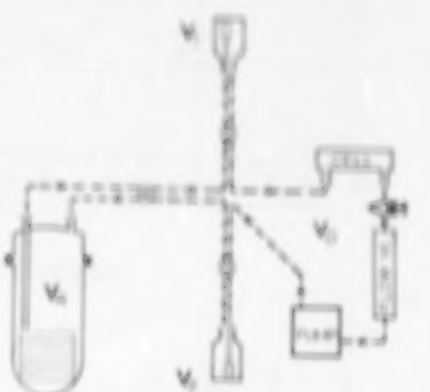

FIG. 1. An on-line atomic absorption spectrophotometer is incorporated into a closed loop fitted with a valving arrangement permitting either flushing or selective switching into a modular bioreactor (V_R, volume 4 liters) containing bacterial isolates on metal-doped synthetic growth media, or into calibration BOD bottle V_1 or V_2 (reprinted from ref. 1).

TABLE 1
Tolerance of Pseudomonas sp. to metal ions

Metal	Tolerance (ppm)
Al(III)	1000
As(V)	10–50
Co(II)	50
Cr(III)	10
Hg(II)	50
Mg(II)	<10⁴
Pb(II)	100
Sn(II)	10
Sn(IV)	1000
Te(VI)	10

†NBS guest worker, 1973–74.

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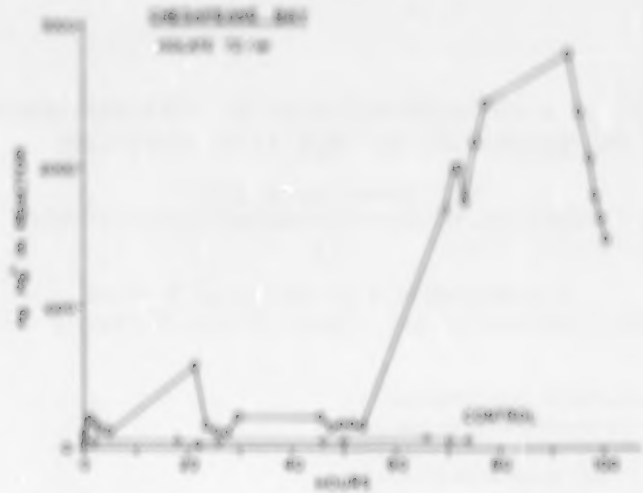

FIG. 2. Common metallic mercury production from a Chesapeake Bay aerobic culture as a function of time, determined by the bioreactor atomic absorption spectrophotometer apparatus shown in Fig. 1. Diameter of open circles represents ± standard deviation in mercury calibration curves used.

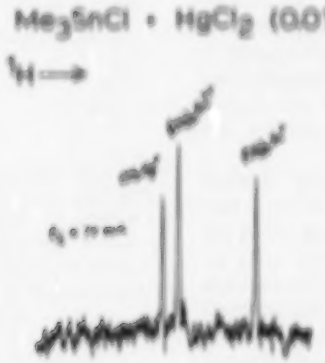

FIG. 3. Proton nuclear magnetic resonance spectrum of intermediate mixture achieved by reacting aqueous solutions containing equivalent amounts of trimethyltin chloride and mercuric chloride. Half-life for the complete reaction was about 70 min (ref. 4).

trolled atmospheres. These results are published elsewhere.[3]

One of the isolates, a strain of *Pseudomonas*, demonstrates a tolerance (Table 1) to a variety of other metal cations in agar media. The possibility of volatilization of these metals by this organism is currently under investigation since other transport pathways similar to mercury transformations may be involved.

Related nonbiological pathways for methylation of mercury have been demonstrated with a number of aquated methylated metal cations.[4] These processes are identified and their rates determined by nuclear magnetic resonance and laser Raman spectroscopy (Figs. 3, 4). We view such alternate transmethylation processes for mercury as important to understanding the overall rate of several metals interacting in aquatic media. We are directing

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16. Abstract (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

Nine phenylmercuric acetate-tolerent bacterial strains, isolated from the Chesapeake Bay were found to produce metallic mercury from phenylmercuric acetate using a flameless atomic absorption spectrophotometer on-line with a bioreactor. Tolerance levels of one Pseudomonas strain to 10 metal ions were reported. Nonbiological methylation of a number of aquated methylated metal cations were studied using nuclear magnetic resonance and laser Raman spectroscopy.

17. KEY WORDS (six to twelve entries; alphabetical order, capitalize only the first letter of the first key word unless a proper name; separated by semicolons): Bacteria; elemental mercury; flameless atomic absorption spectroscopy; laser Raman spectroscopy; nuclear magnetic resonance spectroscopy; phenylmercuric acetate; volatilization

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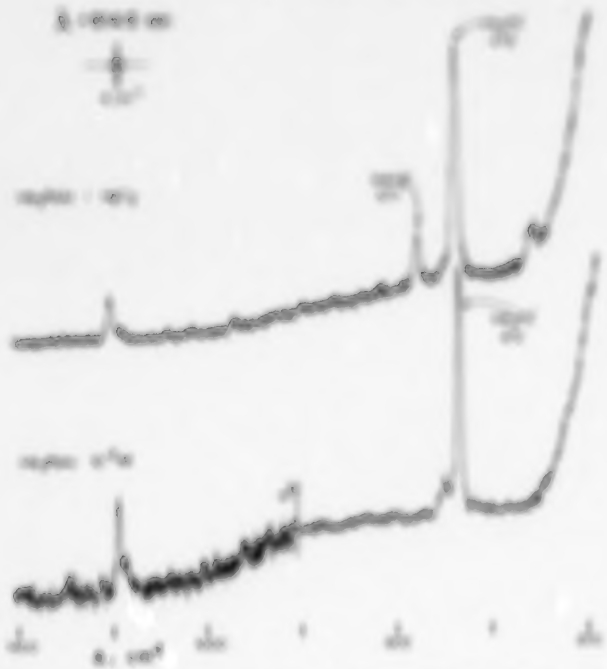

FIG. 6. Comparison of aqueous ionic Raman spectra of reactant trimethylhead acetate solution to that of its reaction mixture with mercuric chloride after several minutes. Product methylmercury ion is readily discernible along with shifted peak for co-product dimethylhead cation (ref. 6).

efforts to establish whether both such biologically and non-biologically transport paths have kinetic importance among those metals cited in Table 1.

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